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The teaching of KS1/2 maths in Irish-medium settings: barriers and opportunities

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**QUEEN'S
UNIVERSITY
BELFAST**

**THE CENTRE FOR
EVIDENCE AND
SOCIAL INNOVATION**

The Teaching of KS1/2 Maths in Irish-Medium Settings: Barriers and Opportunities

This research was commissioned by the CCEA.

September 2018

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Executive Summary

Background

The School of Sociology, Education and Social Work, Queen's University, Belfast, was commissioned by the Council for the Curriculum, Examinations and Assessment (CCEA) to undertake research on teachers' perceptions on how to help the sector develop skills in, and resources for, teaching maths in Irish-medium Education (IME) in Key Stages 1 and 2 (KS1/2). To inform CCEA on how to develop resources for the teaching of maths in KS1/2 in IME, this research explored the views of teachers on the challenges of teaching maths in Irish-medium settings in KS1/2, and the underlying reasons for these difficulties; the pedagogies that teachers find effective for teaching maths; techniques teachers report to be effective; resources teachers would like to use in order to teach maths; and teachers' views on the resources that would support the effective teaching of problem-solving in maths.

Methodology

A literature review was conducted to examine the benefits of bilingualism to children's learning in general, and to learning maths in particular, as well as the relationship between literacy and mathematical skills. The researchers visited six primary schools in Northern Ireland (three urban and three rural) and two schools in the Republic of Ireland (one urban and one rural) across a number of different counties, in May and June, 2018. Where possible, at least one teacher who taught maths from KS1 and one from KS2 were recruited as participants to this study. In total, 11 primary teachers were interviewed.

Key findings

The key findings from this research are that:

- Language proficiency in both the first and target language is integral to the teaching and learning of maths;
- Creative, dynamic, and interactive resources in Irish are urgently desired by teachers;
- Opportunities for continuing professional development in maths pedagogy in Irish-medium settings would be welcomed by the teachers in this study.

1. Introduction

The Council for the Curriculum, Examinations and Assessment (CCEA) is the statutory body in Northern Ireland responsible for all aspects of curriculum development, assessment procedures, examination provision and standardisation for all subjects including Irish-medium Education (IME).

In 2018 the CCEA commissioned Queen's University, Belfast, to undertake research on teachers' perceptions on how to help the sector develop skills in, and resources for, teaching maths in Irish IME in Key Stages 1 and 2 (KS1/2).

1.1 Aims and objectives

The aims of the research encompassed the following:

- To: explore the difficulties of teaching maths in Irish-medium settings in KS1/2, and the underlying reasons for these such as lack of resources and CPD;
- Find out which pedagogies teachers find effective when teaching maths in Irish-medium settings in KS1/2;
- Find out which techniques teachers report to be effective when teaching maths in Irish-medium settings in KS1/2;
- Determine which resources teachers would like to use in order to teach maths in IME, including the sorts of resources that they currently find useful, and the resources that they would like to see provided. In terms of the resources that teachers would like to use and have developed, the focus was on the structure of such resources and the kinds of resources that would build teachers' confidence to deliver maths in Irish-medium settings;
- Generate teachers' views on the resources that would support the effective teaching of problem-solving in maths.

1.2 Autochthonous Medium Education in the UK

Education through the medium of autochthonous minority languages¹, such as Irish, Gaelic, Welsh, in the United Kingdom and the Republic of Ireland, Basque and Catalan in Spain, and Breton in France, have become popular in recent decades. In Scotland, for example, Gaelic-Medium Education (GME) is now a well-established sector in Scottish Education having begun in primary schools in the 1980s. GME is available in 14 out of 32 Scottish local authorities, and immersion education, where Gaelic is the sole medium of education, is available from nursery to the end of primary 3, after which English is introduced. Gaelic, however, remains the predominant language of instruction.

GME is also supported by *The Gaelic Language (Scotland) Act 2005* which secures the status of the Gaelic language as an official language of Scotland commanding equal respect with the English language. Further support for the status of, and education through, the language comes from Statutory Guidance issued by Bòrd na Gàidhlig, under Section 9 of the *Gaelic Language (Scotland) Act 2005*. The aim of the Guidance is to explain the elements that constitute Gaelic education, and to establish a consistent approach and a clear expectation of what GME is, and how it should be delivered². The Statutory Guidance also provides information for parents on how to submit a request to an education authority to assess the need for Gaelic Medium Primary Education.

Education through the medium of Welsh, often cited as a success story in minority language revitalisation, has grown rapidly since the first state funded Welsh-medium primary school opened in 1947. It is the policy of the Welsh Government that all pupils should study Welsh from ages 3-16, either as a first or second language. Section 9 of the *Education Act 1996* states that local authorities must take into account that pupils are to be educated in accordance with the wishes of their parents, so far as that is compatible with the provision of efficient instruction and training. Sections 86, 86A and 86B of the *School Standards and Framework Act 1998* develop the principle of parental choice further. These legislative

¹ Cornish (Kernowek) is a revived language having died out in the late 18th century. In 2014, Cornish was afforded the same status as other minority languages in the UK and the Republic of Ireland under European rules for the protection of national minorities. The Cornish language is the only language in England recognised under the Council of Europe's Charter for Regional or Minority Languages. See <https://www.gov.uk/government/news/cornish-granted-minority-status-within-the-uk>. Manx (Gaelg) is also a Celtic language, the last speaker of which died in 1974, though there have been efforts to revive the language. It is not recognised by the UK government or Council of Europe.

² Bòrd na Gàidhlig (2017) *Statutory Guidance on Gaelic Education*. Available at: <http://www.gaidhlig.scot/bord/education/statutory-guidance/>

provisions are supported by the *Welsh Government's School Admission Code 2013*³, and the *School Standards and Organisation (Wales) Act 2013*⁴, which places a statutory duty on local authorities to assess the demand for Welsh-medium education in their area through Welsh in Education Strategic Plans (WESPs)⁵.

In the Republic of Ireland, the restoration of the Irish language has been a key policy objective of successive governments since the foundation of the State in 1921. In order to halt the decline of Irish, the language was declared the national and first official language of Ireland in accordance with Article 8 of the Constitution of Ireland. English is the second official language. The *Education Act 1998* states, for example, that every person involved in the implementation of the Act should contribute to the 'extension of bilingualism in Irish society and in particular the achievement of greater use of the Irish language at school and in the community' and 'to the maintenance of Irish as the primary community language in Gaeltacht areas'⁶. An Chomhairle um Oideachas Gaeltachta agus Gaelscolaíochta (COGG) was established in 2002 under the provisions of Section 31 of the Education Act, 1998. Its functions include:

- The planning and co-ordination of provision of textbooks and teaching resources through Irish;
- Advising on promotion of education through Irish in schools generally and in Irish-medium schools;
- Providing support services to Irish-medium schools⁷.

With effect from 1 January 2007, Irish was granted the status of an official and working language of the European Union (EU). Irish is taught as an obligatory subject from primary to Leaving Certificate level in the education system.

In Northern Ireland, the Irish-medium sector has continued to grow since the first 'bunscoil' (primary school) opened in 1971 on the Shaw's Road in West Belfast. The school was founded, without the support of the government, by a group of parents. Despite its growth and popularity, late into the 1990s IME in Northern Ireland had not received the same levels of

³ Available at: <https://beta.gov.wales/school-admissions-code>

⁴ Available at: <http://www.legislation.gov.uk/anaw/2013/1/contents/enacted>

⁵ Jones, M. (2016) *Research Briefing. Welsh Medium Education and Welsh as a Subject*. National Assembly for Wales. Available at: <http://www.assembly.wales/research%20documents/rs16-048/16-048-english-web.pdf>

⁶ Education Act, 1998, Section 6. Available at: <http://www.irishstatutebook.ie/eli/1998/act/51/section/6/enacted/en/html>

⁷ *ibid*

state support and funding, particularly from the Department of Education, as had heritage language education in the rest of the UK and the Republic of Ireland. Irish received official recognition in Northern Ireland for the first time with the signing of the Belfast Agreement, also known as the Good Friday Agreement, in 1998. The Belfast Agreement helped to create a more favourable political environment to IME, and called on '[a]ll participants to recognise the importance of respect, understanding and tolerance in relation to linguistic diversity, including in Northern Ireland, the Irish language, Ulster-Scots and the languages of the various ethnic communities ...'⁸. The *Education (Northern Ireland) Order 1998*⁹ states that: 'It shall be the duty of the Department (of Education) to encourage and facilitate the development of Irish-medium education'.

In 2001, the government of the United Kingdom ratified the European Charter for Regional or Minority Languages. Irish (in Northern Ireland only) was specified under Part III of the Charter, giving it a degree of protection and status comparable to Scottish Gaelic and Welsh. The Charter included a range of specific undertakings, including education. Article 8b, for example, enjoins the Parties:

- I. To make available primary education in the relevant regional or minority languages; or
- II. To make available a substantial part of primary education in the relevant regional or minority languages; or
- III. To provide, within primary education, for the teaching of the relevant regional or minority languages as an integral part of the curriculum
- IV. [That the Parties] undertake, if the number of users of a regional or minority language justifies it, to allow, encourage or provide teaching in or of the regional or minority language at all the appropriate stages of education¹⁰.

⁸ The Belfast Agreement, 1998. Available at: <https://www.gov.uk/government/publications/the-belfast-agreement>

⁹ Education (Northern Ireland) Order 1998. Available at: <https://www.legislation.gov.uk/nisi/1998/1759/contents>

¹⁰ Council of Europe (1992) *European Charter for Regional or Minority Languages*, <https://www.coe.int/en/web/conventions/full-list/-/conventions/rms/0900001680695175>. Article 27 of the International Covenant on Civil and Political Rights, adopted by the UN General Assembly in 1966, states that recognised minorities 'shall not be denied the right, in community with the other members of their group, to enjoy their own culture ... to use their own language'. Minority language rights have long been recognised at the international level.

1.3 Irish-medium Education schools in Northern Ireland

According to the Department of Education Northern Ireland (DENI), as of 2017/18¹¹, there are 6,184 pupils in IME, an increase from 5,256 in 2014/16. This includes 319 full-time pupils in nursery classes, a small increase from 315 in 2014/15 and 26 in nursery Irish-medium units, a small decrease from 30 pupils in 2014/15; 4,156 pupils in primary, an increase from 3,458 in 2014/15, and 734 in post primary education, up from 581 in 2014/15. The total figure in post primary schools and units is 1,105, an increase from 913 in 2014/15.

There are 29 Irish-medium schools in Northern Ireland and a further 10 Irish-medium units attached to English-medium host schools. Of the 29 schools, 28 are primary and two are post primary, Colaiste Feirste in Belfast and Gaelcholáiste Dhoire in Dungiven. In addition, there are three post-primary Irish-medium units and two primary controlled schools. Of the 10 Irish-medium units attached to English-medium host schools, seven are primary and three are post-primary. Gaelscoil na Daróige in Derry City teaches through the medium of Irish.

¹¹ Department of Education (2018) Annual Enrolments at Schools and in State Funded Pre-Education in Northern Ireland, 2017/18. Statistical Bulletin, 2/2018. Table 2b.

2. Literature Review

2.1 The value of bilingualism

Early attempts to explain low academic achievement of many minority language children tended to attribute a role to linguistic factors¹². There was an intuitive belief that if bilingual children were weak in one language, the development of their mathematical abilities (and other academic subjects) would be hindered, particularly with word solving problems. The idea was that if word solving problems are derived from ordinary language (as opposed to the unique language of maths), then mastery of mathematical skills is dependent on the mastery of the language in which the problem is to be solved, in Irish or Spanish, for example. Bilingualism was judged to be a source of confusion and an impediment to language proficiency, to the extent that a child paid for her/his second language skills (L2) with a decrease in her first (L1)¹³.

In an early and widely cited study in the literature on bilingualism, Macnamara¹⁴ reported that, while bilingualism had no impact on children's mechanical ability in computational arithmetic, it did impair their ability to solve mathematical word problems. The evidence for the claim came from an overview of the research at the time and from Macnamara's own large-scale study of English-speaking children in Irish language schools, in which he tested word problems in arithmetic. However, as Bialystok¹⁵ points out, the problem was not bilingualism but, rather, 'the use of a language for a complex educational purpose that exceeded the children's proficiency in that language'¹⁶. Children's limited performance in such a task would be hindered whether the child had only one language or many. Linguistic proficiency, in other words 'needs to be adequate for the conceptual demands of the task'¹⁷.

Secada¹⁸ sought to explore the relationship between bilingualism and arithmetic word problem solving among low achieving Hispanic children in the Chicago area, USA. The underachievement in maths of Hispanic children from poor socio-economic backgrounds is

¹² Cummins, J. J. (1979) Linguistic interdependence and the educational development of bilingual children. *Review of Educational Research*, 49/2, pp.222-251.

¹³ Cummins, 1979, p. 222, citing Macnamara's 1967 balance effect hypothesis.

¹⁴ Mcnamara, J. (1967) The bilingual's linguistic development – A psychological overview. *Journal of Social Issues*, 23/2, pp.58-77.

¹⁵ Bialystok, E. (2001) *Bilingualism in Development: Language, Literacy, and Cognition*. Cambridge: Cambridge University Press.

¹⁶ *ibid*, p.109

¹⁷ *ibid*, p.109

¹⁸ Secada, W.G. (1991) Degree of bilingualism and arithmetic problem solving in Hispanic first graders. *Elementary School Journal*, 92/2, pp.213-231.

well documented and many are classified as limited in English Language Proficiency (ELP). The mathematical education provided to low achieving children tends to focus on acquiring basic skills at the expense of problem solving and of other advanced mathematical content. The assumption is that low achieving pupils (in compensatory education schemes in the USA) cannot solve problems before they have mastered the basic skills. Indeed, because the curriculum ignores the competence that first grade pupils possess, many pupils will experience future failure in maths¹⁹.

Secada tested 45 first grade Hispanic children in both Spanish and English for language proficiency and then administered a series of arithmetic word problems to solve in both languages. The children were less proficient in Spanish than in English. Two main findings emerged. First, children could solve the problems equally well in both languages; if they could solve a given problem in English, they could also solve it in Spanish. Second, there was a small but significant effect showing a relation between greater degree of bilingualism and enhanced problem-solving ability. Secada concluded that the problem-solving ability of the bilingual children was equivalent to that of their monolingual peers. His study also showed that lower levels of language proficiency did not interfere with the ability of these children to solve the problems in their weaker language, English.

Using these results to address the question of why this might be case, Secada concluded that the pupil who is less proficient or limited in the second language is *becoming* bilingual and is therefore gaining access to the cognitive benefits that accrue to bilingual children. Children move rapidly between the languages to find a word or concept that can be used to provide meaning or solve problems in the other (the cognitive benefits of bilingualism will be discussed in further detail below). However, it should be noted that the dominant mode of instruction in the Secada study was English, and the dominant language in the United States (US) is, of course, English. The results may be different if [becoming] bilingual pupils are being educated in a minority language and for whom the minority language is their weaker language, as in the case in Northern Ireland and the Republic of Ireland where English is the dominant language.

Secada's study contradicts the findings by Mestre²⁰ who also conducted research with Hispanic-English bilingual children in the US. Mestre identified four forms of language proficiency that are required to solve these problems: (1) ability to read and comprehend a

¹⁹ Secada, 1991, p.215.

²⁰ Mestre, J.P. (1988) The role of language comprehension in maths and problem solving. In R.R.R Coking and J.P. Mestre (Eds). *Linguistic and Cultural Influences on Learning Maths*, pp.201-220. Hillsdale, NJ: Erlbaum.

problem; (2) familiarity with technical language. For example, 'product' has a specific meaning in maths - the operation of multiplication. In ordinary language 'product' means an item to be sold; (3) syntactic proficiency – how mathematical and ordinary language are structured to form a text; and (4) comprehension of math symbols and how they are used in combination with numbers²¹. Mestre claimed that all four proficiencies were compromised in bilingual children, a finding that seems consistent with Macnamara's claim in his 1966 study.

Mestre based his research on Hispanic bilingual children who were studying in English and for whom English was their weaker language. He found that bilinguals with comparable mathematical skills to monolingual children tended to solve mathematical problems incorrectly because of poor language proficiency and had reading speeds slow enough to interfere with performance in timed problem-solving tasks. Further, though two of the language proficiency categories, technical (2) and symbolic language proficiency (4), are domain dependent, to learn these 'languages', pupils must be proficient in the first, English. Not only do pupils need technical proficiency to succeed mathematically, they must first become proficient in English first before they can attain the required technical threshold. Bilingual children are therefore disadvantaged, Mestre claimed.

The children in Secada's should have encountered the problems described by Mestre in his study, but they did not. This seems contradictory but understanding precisely what enhances or inhibits academic competency is complex. According to Bialystock²², if language proficiency in the home language (L1) is at least adequate for understanding the problem, bilingualism should have no effect on mathematical problem-solving. Cummins, in his 1979 research, pointed out that the hypothesis that bilingualism is the cause of academic and cognitive confusion was, even at that time, contradicted by research that showed that bilingualism can positively influence cognitive and linguistic development (see below). Further, socio-cultural effects, or the extent to which the home language is valued and respected by the community, whether teachers are sensitive to the values and traditions of the minority language community, or whether families feel compelled to discourage their children from speaking the home language, may play a more significant role in academic success than simplistic causal linguistic explanations. It may also help to understand how levels of proficiency in either language, both absolute and relative, affects problem solving maths.

²¹ *ibid*, pp.215-216

²² 2001, p.203

2.2 Absolute and relative levels of proficiency: threshold levels of proficiency

Do children who maintain and develop their L1 (English) in school develop higher or lower L2 (Irish) levels of skills than those whose L1 (English) is replaced by their L2 (Irish) as in immersion programmes? Cummins strongly suggested that cognitively and academically beneficial forms of bilingualism can be achieved only if the child has adequately developed first language, or L1, skills.

Cummins based his conclusion on the threshold level of linguistic competence hypothesis, which was an attempt to incorporate proficiency levels into predictions about the effects of bilingualism. This hypothesis assumes that there is a threshold level that bilingual children must achieve in order for the benefits of becoming bilingual to influence their cognitive growth and avoid cognitive defects such as poor word recognition²³. A prerequisite for attaining a higher threshold level of bilingual competence is development and maintenance of L1 skills. The child whose literacy skills is poorly developed in L1 will have difficulties mastering the content of other subjects, especially in subjects which require abstract thought such as maths and the sciences.

Three general aspects of children's knowledge of language which have been hypothesized as important for the acquisition of fluent reading are, first, *Vocabulary concept knowledge*. Vocabulary acquisition and comprehension play a strong role in how well a child can read in either L1 or L2. Teachers who help children explore, interpret and extend the meaning of words thereby develop their reading skills. Although children with low literacy skills can decode the word, the meaning of the word and the concept, the symbol it represents are not available to them, or only in a limited or vague way (and example might be velocity. The child may spell out, decode, vel-oc-i-ty but may not know what it means or how to calculate a problem based on the concept of velocity). Fluent reading comprehension is not possible if the reader does not understand the concept to which the word refers. Further, if the conceptual basis for abstraction is absent in L1 it will be absent in L2.

The second aspect that is important to fluent reading is the acquisition of certain *metalinguistic insights* about the nature of printed text. In order to understand the printed word, children need to understand that print is meaningful and that it is different to speech. Finally and relatedly,

²³ Cummins, 1979, p.330.

the extent to which the child has developed the facility to process *decontextualised language* will determine the child's proficiency in reading. Written text is a representation of meaning ('the rabbit disappeared down the hole') and has a logical and semantic relation between the parts of the sentence (noun [rabbit], verb [disappeared], object [hole]) which the child has to be taught to understand using increasingly complex texts as she progresses through the curriculum²⁴. The child who comes to school able to understand that text is different from the spoken language, that text is meaningful, and who can, to some degree, process decontextualized language, will more quickly take-up the demands of L2 than the child who lacks these insights and facilities. As Cummins concludes. '[t]he fact that the children are already familiar with the concepts encountered in learning L1 means that their task is essentially learning a new label for an already existing concept'²⁵. For example, 'rabbit' in English is 'coinín' in Irish; and velocity is 'treolus'.

Of critical importance is that research has shown that children do not suffer any disadvantages from learning and using two languages, provided that one of their languages is established to age appropriate or proficient threshold levels. Children who have age-appropriate levels in at least one of their languages will have access to the abstract concepts that are the currency of schooling, and which they can transfer to L2. Low thresholds of linguistic competence in one language will impair linguistic proficiency in the other because 'there is no language in which children are able to establish the cognitive systems that are at the base of academic functioning'²⁶. Therefore, if schools are to benefit from children's bilingualism or are to avoid impairment because of it, 'the absolute proficiency level of at least one language is crucial', according to Bialystock. In other words, 'the balance between the two languages is less critical than is the need for one of them to be developed to a level that is sufficient for schooling'²⁷. What matters is the child's proficiency, not when the language is learned, or which language is spoken at home.

Success in school occurs when children develop the native (or L2) language to high levels of proficiency. Children who live in communities where education and achievement are strongly encouraged, and whose family is closely involved with their children's education, can develop high threshold levels of linguistic competence in the native language and, importantly, a positively motivated attitude toward school. Further, when these children attend school in the local language, even if that language is not spoken at home, their immersion is relatively

²⁴ Cummins, 1979, p.237.

²⁵ *ibid*, p.240

²⁶ Bialystock, 2001, p.227.

²⁷ *ibid*, p.228

straightforward and often successful²⁸. Bialystock advises that for children who live in communities where these conditions are not equally available, then the school 'must provide a more supportive and motivating environment to encourage the children and assist them in the educational challenges they face'²⁹.

2.3 The cognitive benefits of bilingualism

Lauchlan, Parisi and Fadda (2013)³⁰ provide supportive evidence of the cognitive benefits of bilingualism. They undertook research to investigate the benefits of bilingualism in children who speak the minority languages of Sardinian and Scottish Gaelic, in addition to their respective national languages of Italian and English. Scottish Gaelic and Sardinian are minority languages, spoken in countries in which English and Italian are recognised international languages. Of note, too, is that most research on the cognitive benefits of bilingualism are undertaken with children who speak in two or more dominant languages (Spanish, French, or Italian, for example), rather than in minority languages (Welsh or Irish, for example).

One hundred and twenty-one children across the two countries, both bilingual and monolingual, were given a series of standardised cognitive ability tests targeted at the four areas that have been shown to be advantageous to bilingual children: *cognitive control*, *working memory*, *metalinguistic awareness* and *problem-solving ability*. Four tests were administered: the Block Design test in which children manipulate coloured blocks to reproduce patterns. It is a test of non-verbal, problem solving ability that requires cognitive control. The Digit Span test requires children to orally repeat a series of numbers in the order presented, then in reverse. This tests working memory. In the Vocabulary test, children are asked to give clear definitions of words. This is a metalinguistic skill of verbal ability and word awareness. In the Arithmetic test children have to mentally solve a series of increasingly complex arithmetical problems. It is a test of mathematical problem solving and working memory.

Scottish bilingual children outperformed Scottish monolingual, Sardinian monolingual and bilingual children on the Vocabulary and Arithmetic tests, and performed significantly better than the two monolingual groups on the Block Design test. Overall, the bilingual children

²⁸ *ibid*, pp.238-9

²⁹ Bialystock, 2001, p.238.

³⁰ Lauchlan, F., Parisi, M and Fadda, R. (2013) Bilingualism in Sardinia and Scotland: exploring the cognitive benefits of speaking a minority language. *International Journal of Bilingualism*, 17/1, pp.43-56.

scored significantly higher than the monolingual children on Block Design and Vocabulary tests. In the other two tests, Digit Span and Arithmetic, the bilingual children scored higher than the monolingual children but not at a significantly statistical level.

The superior performance of the Scottish bilingual children can be attributed to the formal bilingual education Scottish children receive. Scottish Gaelic has legal status in Scotland and bilingual education is available to children from nursery (see Chapter 2). Sardinian does not enjoy legal or formal status, and formal educational provision is not available to them; instead, the language is transmitted informally and does not exist in written form to the extent that Scottish Gaelic does. Scottish children, on Lauchlan, Parisi and Fadda's analysis, are 'balanced' bilinguals to a higher degree than are Sardinian children. Recalling Cummins' (1976) claim that there is a critical threshold of L1 ability that must be attained before the positive effects of bilingualism can be observed, it may be the case, they suggest, that the Sardinian children did not have the same command of oral and written Sardinian as they did in Italian. Lauchlan, Parisi and Fadda concur with Cummins and Bialystock that in order to gain from the advantages of bilingualism, the speaker should be equally proficient in both languages.

2.4 Bilingualism and mathematical competence

Research has also established that bilingualism can benefit children's mathematical competence and achievement, particularly with respect to the development of a child's executive functions (EFs). EFs consist of inhibition (suppressing irrelevant information), updating (working memory such calculating sums), and mental set shifting (from addition to subtraction, for example)³¹. Numerous studies have also demonstrated, with some consistency, according to Hartanto, Yang and Yang³², that bilingual children outperform their monolingual counterparts on EF.

³¹ A widely accepted EF model is that proposed by Miyake and Friedman. See, for example, Miyake A. and Friedman, N. P. (2012) The nature and organization of individual differences in Executive Functions: Four general conclusions. *Current Directions in Psychological Science*, 21, pp. 8-14.

³² Hartanto, A., Yang, H. and Yang, S. (2017) Bilingualism positively predicts mathematical competence: evidence from two large-scale studies. *Learning and Individual Differences*, 61, pp.216-227.

Hartatnto, Yang and Yang, drew on two large-scale datasets collected in the US³³ to examine the relationship between bilingualism and mathematical achievement among preschoolers, kindergarteners, and first-grade students (ages 4–7). In both studies, the researchers found that bilingualism positively predicted teacher-rated mathematical reasoning, emergent numeracy skills, and test scores on either mathematical word problems or standardized mathematical assessments. Further, the positive association between bilingualism and mathematical competence persisted through the transition period from kindergarten to first grade. These results suggest that bilingualism is favourable for children's mathematical reasoning and problem-solving skills.

Marian, Shook, and Schroeder³⁴ examined the effect of bilingual education on mathematics achievement in students from the third (n = 37), fourth (n = 19), and fifth (n = 19) grades of a two-way immersion program that combined the majority language (English) with a minority language (Spanish) in the USA. When bilingual students' scores were compared to those of monolingual students in the third (n = 574), fourth (n = 579), and fifth (n = 624) grades who were enrolled in mainstream classrooms, the results showed that bilingual students outperformed their monolingual peers.

Research has demonstrated a significant relationship between performance on mathematical word problems and language proficiency, and bilingual students with high proficiency in both Irish and English perform better mathematically³⁵. Ní Ríordáin and O' Donoghue conducted research in the Republic of Ireland to specifically examine the influence of language proficiency on performance of mathematical word-based problem solving of Gaeilgeoirí (speaker of Irish) in the transition to English-medium mathematics education at second and third-level education. To do so, 16 P7 pupils were recruited from Gaeltacht schools (Irish speaking areas) and 21 from Gaelscoileanna (immersion schools). A control group of monolingual English-speaking students (n=49) was also used. The bilingual participants at second level had all studied mathematics through the medium of Gaeilge at primary level, were now studying maths through English in their first year at second level education.

³³ The Multi-State Study of Pre-Kindergarten and the State-Wide Early Education Programs (Study 1) and the Early Childhood Longitudinal Study (Study 2).

³⁴ Marian, V., Shook, A., and Schroeder, S. R. (2013) Bilingual two-way immersion programs benefit academic achievement. *Bilingual Research Journal*, 36/2, pp.167–186.

³⁵ Ní Ríordáin, M. and O' Donoghue, J. (2009) The relationship between performance on mathematical word problems and language proficiency for students learning through the medium of Irish. *Educational Studies in Mathematics*, 71/1, pp.43-61.

The participants completed a mathematics word problem test in Gaeilge (bilingual students only) and in English; and language proficiency tests in English and in Gaeilge (bilingual students only)³⁶. The findings revealed that Irish-medium pupils' performance on mathematical word problems is related to their linguistic proficiencies in both languages. Gaeilge language proficiency (the language of learning) was found to be of more significance than proficiency in English, and the pupils' performance on the English version of the mathematics test was highly correlated with their performance on the Gaeilge version of the test. What seems evident in this study is that the greater the level of academic language proficiency in a student's first language (Gaelige), the stronger the transfer of skills across to the new language of instruction (English). However, when assessed through the medium of English, the Gaeilgeoirí experienced a disadvantage of 8.7% in performance on mathematical word problems. Ní Ríordáin and O' Donoghue suggest that improving language proficiency in English may improve the pupils' performance in mathematics through the medium of English. It may also help to assess the student in their first language until they have mastered the language of mathematics in English³⁷. The key findings presented in this paper provide support for Cummins Thresholds Hypothesis discussed above.

National testing in mathematics and English reveals that students in Irish-medium primary education perform the same or better than students in all English-medium education in both mathematics and English³⁸.

2.5 Language-as-resource

The specific role of language in the teaching and learning of mathematics in bilingual contexts is now well established³⁹. Research has helped to undermine the belief in language-as-deficit and orientate it towards language-as-resource whereby linguistic challenges are seen as learning opportunities. Language-as-resource is defined as '...a language-specific orientation consisting of the use of students' languages in classroom activity in ways that allow and maximise the generation and exploitation of maths learning opportunities'⁴⁰.

³⁶ For example: 'In a class of 30 girls, 17 play tennis and 15 play netball. If all the girls play at least one of these games, how many girls play both?' See Appendix A, *ibid*, p.59.

³⁷ *ibid*, p.56

³⁸ Gilleece, L., Shiel, G., Clerkin, A. and Millar, D. (2012) *The 2010 National Assessments of English Reading and Mathematics in Irish-Medium Schools*. Dublin: Education Research Centre.

³⁹ See, for example, Planas, N. and Civil, M. (2013) Language-as-resource and language-as-political: Tensions in the bilingual mathematics classroom. *Mathematics Education Research Journal* 25/3, pp.361–378. doi:10.1007/s13394-013-0075-6

⁴⁰ Planas, N. (2014) One speaker, two languages: learning opportunities in the Mathematics classroom. *Educational Studies in the Classroom*, 87/1, pp. 51-66. (p.55).

An important strategy in the execution of language-as-resource is the deliberate and targeted use of teacher communication of mathematical concepts, words, statements, and problems in the target language. Research by Khisty and Chval⁴¹ explored the role of teacher talk on bilingual students' learning in the mathematics classroom and emphasised the critical role of the teacher in the communication process. Specific strategies that the researchers recommended included: intentional use of the teacher's mathematical talk; understanding that speaking mathematically is central to the learning of mathematics; encouraging students to use complete statements; using mathematical words in teacher talk; and ensuring that pupils know the meaning of key words and concepts⁴².

Planas⁴³ suggests that language-as-resource consists in the use of students' languages in classroom activity that 'allows and maximises the generation and exploitation of mathematics learning opportunities'⁴⁴ for thinking and doing, and particularly for learning and teaching mathematics. With respect to minority languages, language-as-resource can also 'have a direct impact on enhancing the language status of subordinate languages'⁴⁵.

Ní Ríordáin⁴⁶ develops the concept of language-as-resource in her research by considering how specific features of the Irish language can facilitate conceptual development in mathematics and can aid the acquisition of mathematical skills in Irish-medium settings. Ní Ríordáin argues that general syntactical features of the Irish language, such as sentence length, topic prominence and word order, lend themselves to easier interpretation of mathematical meaning in comparison to English. For example, many mathematical Irish words describe objects rather than simply label them. 'Velocity' in English means speed. In Irish, the conceptual and descriptive equivalent is 'treoluas', meaning 'direction speed' or 'the speed of something in a given direction'⁴⁷. The descriptive aspect of the word makes it easier for

⁴¹ Khisty, L. L. and Chval, K. (2002) Pedagogic discourse and equity in mathematics: when teachers' talk matters. *Mathematics Education Research Journal*, 14/3, pp.154–168.

⁴² *ibid*, p.7

⁴³ Planas, N. (2014) One speaker, two languages: learning opportunities in the language classroom. *Educational Studies in Mathematics*, 87, pp.51-66. P.55

⁴⁴ *ibid*, p.55

⁴⁵ Ruiz, R. (1984) Orientations in language planning. *NABE Journal*, 8/2, pp.15–34, cited in *ibid*, p.55.

⁴⁶ Ní Ríordáin, M. (2018) Exploiting the potential of bilingualism: Irish-medium primary mathematics teachers' self-reported practices in relation to utilising language-as-resource. *Irish Educational Studies*. doi 10.1080/03323315.2018.1471408

⁴⁷ *ibid*, p.5

children to understand the conceptual meaning of the word, and so process the problem. Other features of the Irish language which supports language-as-resource is the word order in relation to number. Irish counts in units of ten. 43 pens, for example, is *tri pheann is daichead*, or three pens and forty. As Ní Ríordáin explains, the name, *peann*, is in the singular not the plural (*pinn*) form, and plurality is expressed by the adjunction of a number. While the word order in counting could be challenging because it is so different from English, it is an opportunity to think about number sense and order.

In order to examine Irish-medium primary teachers' practices in teaching maths through the medium of Irish, Ní Ríordáin⁴⁸ surveyed 315 teachers from 77 Irish-medium primary schools on teachers' self-reported practices on 'language as resource'. The findings revealed that the majority of teachers (92%) recognised the importance of teacher talk in the classroom.

However, only 36% of teachers reported using practices that reflected an understanding of how their talk affects bilingual students' learning in maths lessons. Teachers who understood that language is a resource for teaching maths did not simply rely on teaching terminology, but structured the learning through peer discussion and communication tasks, as this respondent from the study explains:

I ensure that I use the correct maths vocabulary when explaining, use it throughout the maths lesson and insist on my students using the correct vocabulary and ways of explaining also'. T87, Gaeltacht⁴⁹

On the other hand, respondents who did not use language to structure mathematical learning typically suggested that 'It's just about showing them the steps and getting them to practice the maths' (T155, Gaeltacht); or, that it is '...difficult to talk about maths, they just need to do maths' (T166, Gaelscoil).

In response to the question: 'Does the Irish language help develop mathematical concepts?' 41% said 'yes'. Explanations of how the language helps focused primarily on vocabulary and how some of the words describe the mathematical idea: 'Some of the mathematical words actually convey the idea and it can be very useful to highlight this to pupils' (T55, Gaeltacht). However, 87% of respondents were unsure how syntactical features and specific characteristics of the Irish language could be used to support the teaching of mathematics: 'I never really thought about sentence structure and where key mathematical terms might come

⁴⁸ *ibid*, 2018

⁴⁹ *ibid*, pp.10-11

in a sentence. It could actually help with teaching say word problems' (T144, Gaeltacht); 'It's not something (placement of digit and word order) that was ever highlighted to me in terms of teaching maths through Irish. It could be useful but I would need to develop my own knowledge first!' (T10, Gaelscoil)⁵⁰.

Talking, arguing, and explaining are quality practices that let the students gain autonomy from the teacher and become active in communicating their mathematical thinking in either language:

There is a difficult balance to be struck between attention to mathematics and attention to language, where the latter includes not only vocabulary, but also broader aspects of language such as mathematical ways of talking, arguing and explaining⁵¹.

In order for teachers to exploit the benefits of bilingualism and classroom opportunities for learning, resources and professional development programmes need to be established that incorporate the development of pedagogical approaches that support a language-as-resource orientation. Vocabulary development is one measure of language proficiency, but approaches that are overly focused on vocabulary acquisition and translation constrict opportunities to use the language as a resource, and hinder pupils from learning maths. Teachers in Ní Ríordáin's research reported a lack of confidence in teaching contextualised problems because of language difficulties, suggesting a language-as-problem rather than language-as-resource orientation. Furthermore, since many of the responses were centred on linguistic difficulties, particularly of students with special education needs, opportunities to regard Irish-as-resource to teach maths were restricted. Developing a mathematical concept in one language should allow for that concept to be accessible in another language. However, both the mathematical concept and language need to be developed concurrently.

⁵⁰ *ibid*, p.12

⁵¹ Barwell, R. (2009) Multilingualism in mathematics classrooms: an introductory discussion. In: R. Barwell (Ed.) *Multilingualism in mathematics classrooms: global perspectives* (pp. 1–13). Clevedon: Multilingual Matters. p.7.

3. Methods

3.1 Data collection

Before the research began, the researchers met with CCEA officials in February, 2018, whose specific remit is Irish-medium Education to determine the focus, methodology and sample size of the research. In February, 2018, the researchers also attended a meeting at CCEA with the IME maths advisory group to obtain insight into what resources teachers perceived would be useful to help the sector develop their mathematics teaching in Irish-medium schools.

The researchers visited six primary schools in Northern Ireland (three urban and three rural) and two schools in the Republic of Ireland (one urban and one rural) across a number of different counties. The schools had previously agreed to participate in the research through CCEA and were contacted via email to obtain written consent. Following the acquisition of written consent, a suitable time and date was scheduled to visit the school.

Semi-structured interviews were used to enable an open and explorative means by which to understand the issues facing teachers involved in teaching maths in KS1/2 in IME settings. The interviews were conducted on-site, by two researchers (from a team of four) based at Queen's University, Belfast. The interviews took place with key staff from each school between May and June, 2018. Where possible, at least one teacher from KS1 and one from KS2 maths were recruited as participants for this study. In total, 11 primary teachers were interviewed for approximately one hour each (see Appendix 2). Interviews were digitally recorded for transcription and then anonymised to protect the respondents' identities. Interview recordings were deleted following transcription.

3.2 Data analysis

Interviews were analysed thematically to draw out key concepts and themes. A degree of fluidity was applied to the analysis so that emerging concepts outside of the research questions could also be examined. The transcripts were independently screened for emergent themes by two researchers. Verbatim quotes were extracted which epitomised emerging themes and are presented in the findings chapter.

3.3 Ethics

Ethical approval for the research was granted by the School of Sociology Education and Social Work, Queen's University. CCEA facilitated access to the schools in Northern Ireland and the Republic of Ireland. The selection criteria of the participants was guided by the following considerations: the teachers of the schools met regularly with CCEA to discuss

curriculum and assessment issues; the participants were teachers of KS1 and KS2 maths; and had to be Irish speaking maths teachers working in IME schools.

Active and voluntary consent was obtained by providing participant teachers and the Principals of the schools with an information letter explaining the purpose of the research (see Appendix 1). The participants received the introductory letter and information letter by email. The interview schedule was sent in advance of the interview. On the day of interview the purpose of the research was verbally recapped to each participant prior to them signing a consent form.

Further, though CCEA facilitated access, non-attribution of quotes or descriptions will ensure that the relationships between the schools and the commissioning agency is not compromised.

4. Research findings

4.1 General challenges in IME

A number of general challenges emerged in this research, including the need for numeracy interventions, numeracy training and support for teachers, though not specifically in IME. There is little reinforcement of Irish mathematical terms as these are not used outside of school hours. Teachers are also concerned about the level of maths preparation in Irish for post primary transfer and whether this should be supported by teaching the concepts in English. In addition, consistency in the use of mathematical terms in Irish also cause some concern as these can vary from one region to another.

In terms of support, one teacher highlighted this issue in the context of both children and teachers:

There's no support for numeracy of children who have numeracy difficulties. Teachers are very often left to their own devices. There's nowhere to go to seek support beyond the confines of the school; there's no proper teachers. This is, in general, in English and in Irish. (*Teacher 3*)

School staff discussed difficulties that arose during the latter years of primary school, as well as through transition from primary to secondary education. One teacher highlighted the lack of opportunities outside of school settings to use and reinforce pupils' linguistic skills:

The other issue I'd come across, especially at the top of the school, would be re-enforcing their maths at home or experiencing their maths in real life situations. So we're teaching them maths and maths skills in Irish but they don't always have those opportunities to use it specifically through an Irish-medium setting outside of the classroom walls. (*Teacher 6*)

In terms of using mathematical talk, another teacher considered inconsistent use of vocabulary and phrases and the difficulties in grasping more advanced mathematical concepts upon entry into post-primary education:

The problems seem to accumulate when they go to first year in college and I know the Head of Maths there was saying to me, 'hmmm, some children might've been used to using certain phrases and some children are used to using other phrases, and there maybe wasn't consistency'. (*Teacher 6*)

Preparation for post-primary/secondary education also raised questions for staff as to whether teaching should include more integration of the English language in order to facilitate those moving into English language settings:

Most of our children are transferred into Irish-medium secondary and then that's always a debate with teachers at the top of the school: do you prepare them to go to an English medium secondary school? Or do you continue to teach everything through Irish [because] that's the school they're in? You know, some teachers would argue at the end of P7 you should be teaching them both. (*Teacher 6*)

4.2 Literacy (problem solving through the use of a second language)

There was some concern that children who struggle with literacy also struggle with mathematical concepts and understanding written problems. However, some of the teachers suggested that this problem is not confined to the teaching of maths in IME but is, rather, a problem in any setting:

The problem is presented [when the maths problem is] written down and it's a language problem, so the first thing you've got to do is to do with the language. And if you haven't got that basis in language, and even ... to be comfortable enough with the

language, that it doesn't become a block and that you can deal with the actual concept behind it, well, then the language prevents you even getting to that second stage where it's really sort of mathematical thinking or solving the problem because you're stuck with the language. *(Teacher 1)*

Difficulties with language and grasping mathematical concepts were particularly evident when considering problem solving:

Problem solving is a big area that comes up all the time when we go to numeracy clusters. That comes up as a huge difficulty for people to teach and to see some kind of progress with the children so ... questions in worded form, this keeps coming up as an issue. Because you have two tasks: you have the task of reading and of understanding; and then you have the task of maths – 'what maths do I have to engage in to get this answer right?' *(Teacher 6)*

One teacher provided a practical example of difficulties grasping the language and the impact of then solving a mathematical problem:

They would have difficulties, I suppose, yeah, because if they have reading difficulties it's going to be really challenging for them to read something that's two or three lines long. And asking them something. They'd have no problem if you said to them, 'okay that one there you need to multiply to twenty three by six'. But if they have to read the thing, in word form, you know they might divide it or they might subtract, or they might just not really try at all because it's just too difficult. *(Teacher 5)*

Another participant felt that the challenge centred round the actual teaching of maths through IME. However, like others, this participant agreed that children's grasp of mathematical talk and language was imperative when it came to problem solving:

The difficulty is actually the maths rather than the language but the language for problem solving or for reading questions even – it's probably a language experience. *(Teacher 1)*

As already mentioned, some staff reported that these challenges were not unique to teaching maths through IME:

So you will get this problem in English speaking schools so your children who have a greater struggle in reading are going to find worded maths problems difficult because they've to get over the hurdle of reading it first – there's also, then, the second task of understanding it. (*Teacher 5*)

4.3 Home support/parental ability in Irish/maths

In general, there was concern that parents dismiss children's difficulties with maths because it is socially acceptable to struggle in this area. Teachers reported that children who struggle with literacy face further disadvantages if their parents are not proficient in the Irish language:

If you say 'your child's having difficulty in maths', they'll turn around and say, 'well, no wonder! I was crap at maths myself'. Nobody ever goes, if you say they're having difficulties with literacy, 'aww I'm crap at reading myself'. You know, it seems to be okay not to be good at maths. (*Teacher 4*)

Capacity for parental support and reinforcement of learning in the home environment was considered challenging:

The other thing, I suppose, [that is] challenging about teaching maths in Irish is parents sometimes have a difficulty with it because, again, we're teaching in Irish so they're going home to do their homework and if they have a difficulty, in a lot of cases, parents aren't able to help them. So, they're coming in saying, 'look we just couldn't help them because we don't really know what those words mean or how to do that'. (*Teacher 10*)

So they're only [the children] dealing with this other language from nine to three, or whatever, and then they're going home and that's it until they come back to school again. Do you know what I mean? That can be a problem for weaker children. (*Teacher 10*)

Yes, it is a little harder for our children because, say, if they're taking these worded problems home as homework, they don't always have the support at home for somebody to break it down and read it for them, or help them with their reading, depending on the level of Irish their parents have. (*Teacher 6*)

One teacher also discussed how capacity for parental support can decline as children become more proficient in the Irish language:

Another problem I come across is re-enforcing maths at home so maths homework, and stuff like that, it's more of an issue maybe with just homework in general. Sometimes children, when they get to the top of the school, they become more fluent in Irish than their parents ... so their parents get to a point where they feel, like, they can't help them anymore, or its difficult to help them. (*Teacher 6*)

4.4 Availability of resources, CPD and qualified Irish speaking teachers

Interview participants expressed concerns around resources with respect to availability, time for teaching preparation, opportunities for personal development and overall adequacy in education and training for those entering into the teaching profession, particularly in relation to the delivery of mathematical teaching.

In terms of tangible resources, one teacher highlighted the inaptitude of available material:

We do find that any of the online resources that are available in Irish are very, very basic, language based ones for junior infants, so, learning how to count or learning how to sort. There's very few as you go up, very few. (*Teacher 10*)

Teacher education may be affecting teachers' confidence to teach maths which, consequently, may be transmitted to the pupils. Further, most teachers who enter into IME are predominantly linguists (usually Irish, French or Spanish), which compounds the problem of teaching maths with confidence and skill:

One thing that you'll maybe find in an Irish-medium school that isn't in mainstream or English medium schools, is that everybody who works in the school will have a qualification in Irish, they'll be linguists in Irish. ... so we would have very few teachers, I think, within the sector who have a mathematical qualification. (*Teacher 4*)

... with the core teaching body coming through ... everybody is a linguist in the Irish-medium education sector but they're also a teacher of maths; and they're also a teacher of science and ... you know, they have to have many strings to their fiddle. When you're a primary school teacher you are not subject specific. (*Teacher 6*)

Generally, according to teachers in our sample, training opportunities for IME teachers, and in particular for maths, is limited due to the lack of courses provided in Irish. Even if there are courses available for CPD maths, schools struggle to attend them because there are few Irish speaking teachers on the substitute register to cover the classes:

There is a lack of CPD in Irish, in teaching maths in Irish, anyway, full stop. Any of the CPD we've done in maths has been through English. We've got one [Irish maths specialist] that came in and we had to get them up from Galway because we desperately needed someone to ... show us what's out there. But all the other CPD has been done in English. *(Teacher 10)*

I know our problem even is when there's been sub-cover there there's not much flexibility in the kind of pool of substitute teachers that are out there for the sector at the minute, so there's maybe four or five on our list, and if they're not available you just can't go on the course then. *(Teacher 6)*

The research also reveals teachers' frustration with the lack of resources available to them to supplement their teaching of the subject in Irish, particularly when they compare their situation to what is available for use in English-medium schools. Teachers access maths resources in Irish, even simple text books. Additional resources are very limited so that many teachers use online English resources with the sound turned off. Teachers also individually try to collate their own resources to fill the resource gap, particularly with interactive and practical online resources. There is some overlap between challenges highlighted by teachers and suggestions to overcome these issues, as will be addressed later in the report.

4.5 Suggestions on how to overcome challenges to teaching maths in IME

Teachers reported using a number of resources in order to teach maths through the medium of Irish, including text books, iPads, visualisers which display mathematical problems on white boards to show objects in detail (such as using a protractor to measure angles), interactive whiteboards and concrete learning materials such as counting blocks.

Though text books were described as useful resources they generally served as prompts for for active teaching with concrete materials:

The thing I would use most in maths is the visualizer which is when you put down whatever is in the book or the accompanying materials on a visualizer and it will come up on the whiteboard for the kids. So you use the text book maybe as a guide. So, say you're going to do decimals, with the white board you kind of use it to show them the concrete materials so things like Dienes blocks, all this sort of stuff you can put them on the visualizer. *(Teacher 5)*

I'm not constantly making up problems if they're not reading problems from a book, that they can see them in a more visual way maybe, if they were kind of interactive games. *(Teacher 5)*

A more interactive and visual approach to learning was deemed necessary to assist learning above and beyond that which is offered through text books:

What we do ... we teach maths one day a week with no text book. And I think that whole emphasis on text books never does maths any service anyway. *(Teacher 1)*

Teachers reported using electronic devices, in particular Ipads, on an individual basis as a useful resource:

They had iPads and...it was just, actually it was all problem solving. And they were great because it was just puzzles after puzzles and it was terrific. *(Teacher 2)*

However, the dearth of apps considered adequate for teaching maths through IME was described by some as a stumbling block, particularly with respect to workload and the burden associated with translating and adapting content from English to Irish:

We're lucky in this school, I suppose, that we do have interactive boards in every room. We have iPads, but there's a limited amount you can do with this stuff because of the fact that we are an Irish speaking school and we're trying to teach mathematics through Irish. *(Teacher 10)*

The participant went on to elaborate:

So Numicon is very good, it's excellent. And we've been trialling a thing called IZAK9 this year, which is very good ... it is an English programme but we've been using it through Irish, obviously. And then this year too, with the new coding and this emphasis

on coding in maths, we've been trialling this new thing called BeeBots and it's very good for coding for the junior classes So these new resources that are coming out for coding is all in English. So we have to do very heavy work on them ... we had to change so much stuff on it. You know, there was nearly too much work from the teachers to kind of get them ready to use here. It was an awful waste of two months, because it is a very good programme and, you know, we wanted to use them and, you know, and it connects with the iPads But the problem with that was the app was full of English ... we just can't do that you know. (*Teacher 10*)

One teacher reported using a more adaptable app. However, despite the advantages described, it served merely as a platform for interactive learning and required teachers to develop and input content:

So they were all thinking that was something that is lacking and, you know, like, I've noticed that a lot of the teachers were using the site 'Kahoot' to reinforce and assess what they learned in maths. Now, the beauty of Kahoot is that you can put in your own language, you can make up your own questions, and it is excellent. I saw it actually in action yesterday, where they had just done charts and the teacher had a fifteen question quiz ready, but it was just an amazing assessment on Irish and on the maths. Because all the children with their iPads, the questions were coming up and then after every question they would come up for all of them, you know, seven got it right and this is where it was pupil led and they were able to discuss, 'well, why did they put this answer and that answer?' and it was very, very good but wouldn't it be fantastic if that was there in Irish? (*Teacher 10*)

Teachers made a number of suggestions to overcome existing challenges associated with teaching maths through IME. Suggestions centred around resource/capacity for parents to better support children in the home environment, improving teacher competence, increased training and adequate staffing to facilitate this, provision of resources that are both fit for purpose and adaptive, and an agreed framework to offer structure and guidance for teachers. These suggestions are discussed in more detail below.

As highlighted in the challenges of teaching maths through IME, discussions with school staff suggest that capacity for parental support can serve as a barrier to learning:

The other thing, I suppose, that is challenging about teaching maths in Irish is parents sometimes have a difficulty with it because, again, we're teaching in Irish so they're

going home to do their homework and if they have a difficulty in a lot of cases, parents aren't able to help them. So, they're coming in saying, 'look we just couldn't help them because we don't really know what those words mean or how to do that'. (*Teacher 10*)

One teacher suggested improving parental support and discussed her own strategy to address this:

So maybe it's just a case of it being further and better parental support too ... for us it is a wee bit more difficult because it's not in the home setting, majority of the time too. (*Teacher 9*)

To provide further support for parents, this teacher would record mathematical words and numbers in Irish so that the parents could listen to them at home, as well as listen to their child reading:

I would record the children reading [on an Iphone] and every child has a profile and it can only go to that parent. So I would record them reading so their parents can hear them. ... I do the numbers too and then what we would also do is, and I do it for the numbers as well and for basic maths terms like 'addition' or whatever, we would do it, the word, the pronunciation and the English, and that goes home at the start of every year. (*Teacher 9*)

Teacher competence and confidence, staff resources and increased competence in language were also reported as essential to overcoming existing challenges:

One thing that you'll maybe find in an Irish-medium school that isn't in mainstream or English medium schools is that everybody who works in the school will have a qualification in Irish, they'll be linguists in Irish. So, therefore, your number of teachers who would've been good at numeracy at school, you know the way it is, it doesn't go right across the board, but they're linguists ... so we would have very few teachers, I think, within the sector who have a mathematical qualification.

Another challenge, maybe, is our own proficiency in numeracy, that if we don't feel confident in numeracy, then does that come across in the way that we teach? And on the flip side of that, if we're really proficient in numeracy do we understand the difficulties that the children have? (*Teacher 3*)

Alongside improving competence was the need for continuous professional development (CPD) and the capacity to facilitate CPD through provision of linguistically competent substitute staffing:

I think the best resource you always have is teachers. And the best investment is always CPD and ... if you were to work out how much is put into it ... say very little.
(Teacher 2)

That's another, you know, thing that comes up, the kind of training and continuous professional development for teachers in maths, especially recently. The courses are few and far between, specifically for Irish-medium maths, you know. I've been on a course or two this year but for general things, new Makaton and things that are offered to any school. But I do think, and maybe even focusing in on our NQTs, our newly qualified teachers and the young teachers coming out, that they do have an opportunity to go and have, you know, maybe an intense course day where they focus in and practice their language ability through their maths work. Lots of people wouldn't be confident with it and there's very little support for it apart from going home and doing your own study and brushing up. You know that would be great [CPD in Irish] if it could be part of the NQT training for Irish-medium teachers specifically. (Teacher 6)

We would find that there is a lack of CPD in Irish, in teaching maths in Irish, anyway, full stop. Any of the CPD, we've done in maths has been through English. (Teacher 10)

Better training, initial teacher training, that they're prepared. I felt sometimes it was a lot of knowledge that we were being given rather than the practical steps to teaching numeracy in the classroom. (Teacher 3)

In terms of how to overcome challenges, teachers referred to provision of resources that were fit for purpose with capacity to adapt to a range of ages and abilities. Staff also suggested sharing information and resources through an online platform. These suggestions are discussed in more detail in the following section.

Some staff highlighted the need for a structured language framework to offer guidance to schools:

Well ... some sort of language framework that could give you some sort of guidance generally. It's not gonna be ... you know, every single word is not going to be covered on a language framework, but if we could give schools a general idea that we were all following the same kind of plan – things get very complicated in P7, up at the top of the school, they are maybe not as complicated in English, you have a lot of words that would need to be moved into genitive cases ... for the sentence to be grammatically correct. (*Teacher 6*)

In response to an absence of a framework, schools developed their own strategies:

Now we've been putting in new strategies, two years ago, and we've put new ones again this year and they have begun to bear fruit, and what we've been doing is we've been with the children, kind of exploring problems and listening, you know, for, like, key words and stuff. You know, and what do those words mean, you know? And that seemed to kind of work, especially with our middle group this year ... we've been teaching them all year, you know, different little strategies, like certain words sometimes mean that you're probably going to be looking to be adding stuff here So, if you see the words, you know, all together or, you know, how many in total, well therefore, you know, maybe they're asking you to look for the whole picture. (*Teacher 10*)

4.6 Suggestions for online maths resources

In terms of suggestions for online resources, IME teachers discussed the importance of language in learning mathematical concepts, with particular emphasis on problem solving:

I think language, mathematical language, would have to be key to it. It's the one thing that we don't have. You know, I don't think there's a point in having a game that's just numeracy based like, you know, two plus two equals ...? and you've to pick the number because there's billions of them available in English. So something that was definitely re-enforcing the mathematical terminology, whilst also re-enforcing the concept. But something [a game] based just purely on the concept ... to me we can get already. So yeah, it would have to be focused around terminology. (*Teacher 4*)

Well first that there would be an emphasis on the language so that it would be a rich language ... don't just give them the basics, they need to experience the abstract, awkward language, and they need to be able to read it and experience it often. That

there would be problem solving activities [in the resources] so language based problems. (*Teacher 6*)

A number of teachers discussed the importance of adaptive learning through online resources. For example:

Re-enforcement of certain concepts that children were finding difficult to grasp, [so] that they could go off and practice, and they could maybe hear that language again and again on their own, maybe with a set of headphones ... they could work on that and the teacher could work on another group within the class after the class teaching as such, then that would allow ... the teacher to meet the needs of all the groups, but again it's [online resources] not necessarily taking the place of that interaction that happens between teacher and pupil. (*Teacher 3*)

Even when teachers are looking at maths resources online they do tend to kind of go, 'is there anything in Irish in it?' The answer is usually 'no', but every so often you do hit something that's, that has Irish in it which is great. We do find that any of the online resources that are available in Irish are very, very basic language based ones for junior infants, so, learning how to count or learning how to sort. There's very few [resources] as you go up, very few ... So, that's the first thing, that there would be resources out there for this senior class that actually has a good level of Irish in them as well. (*Teacher 10*)

An online resource, you know, even if you are talking with a certain age group, they'd love to see three or four levels of difficulty so that the children who are very, very good at maths are still challenged. As are the kids who are struggling, but they're still all on the same team. (*Teacher 10*)

Teachers highlighted the value of information sharing and knowledge exchange at a regional level through the medium of online platforms. It was anticipated that such a resource would reduce individual workload in terms of producing classroom resources and promote peer learning among teachers across the country.

We spend a lot of time translating resources and creating new resources ourselves in school. (*Teacher 7*)

Clubbing together with resources and things – I know some schools have tried to do it before but I'm sure there's many a teacher sitting at home making maths resources that somebody else is having sitting at home, again, somebody else is doing in Ballycastle, somebody's doing in Kilkeel, somebody's doing ... you know, some kind of central bank for resource. (*Teacher 6*)

Yeah, well I would have contacted Gaelscoil or Gael Agus Gall which is an umbrella organisation which takes in the North and the South of Ireland and I've said this, they have the capabilities, they have people employed full time, do you know? They need to do that, they need to set up a sharing site and just, you know, manage it nicely ... that's Irish, English, and let people add stuff. They'd be very little, like, administration and stuff like that, like, apart from making sure no-one's putting up stuff that's inappropriate, and it would be literally teachers uploading their own stuff, saying 'listen, I use this, I made this'. (*Teacher 10*)

Whilst the majority of teachers discussed the value of a tailored and adaptive online resource to teach maths through IME, one teacher highlighted the technical issues associated with digital learning and expressed a preference for traditional means of teaching:

I prefer to have a paper and pencil element because not every teacher can access IT equipment every day. We do have an issue with our IT. In many schools it's not always working Everybody's understaffed nowadays and can't get people to come out when you want them to. So very often our machines are down or they're very slow or they don't work or the children can't log in. (*Teacher 7*)

In summary, what the research here shows is that teachers are Irish enthusiasts, keenly aware of the difficulties of teaching maths in KS1/2 in IME but who do all they can to adapt whatever resources they do have to creatively teach maths. Among the key challenges are that resources in Irish are few, whether texts or interactive; children's mathematical competence is affected by poor linguistic skills, problems that are compounded if their parents' language or mathematical skills are lacking, or teachers lack confidence in teaching maths. There are, in addition, few opportunities for CPD in Irish language development or maths teaching; and the profession is dominated by linguists, many of whom may not be confident or skilled in teaching maths.

Teachers have responded to these challenges by, for example, using and adapting interactive resources whenever they can, translating resources into Irish, and using mobile phone

technology to communicate with parents. Teachers would welcome new interactive resources in Irish and would willingly pilot these were CCEA to develop them.

The next chapter will discuss the research findings with respect to what the wider research literature has shown about the acquisition of language and mathematical skills.

5. Recommendations

5.1 Language skills

As previous research has established (see Literature Review), bilingualism can positively influence cognitive and linguistic development, and positively influence children's mathematical skills⁵². It is also very well established in the research literature that language is key to learning maths, and a key issue in the teaching of mathematics⁵³. However, the teachers who participated in this research reported that many of the teachers who come from teacher education courses are linguistics, rarely mathematicians, which can impact on the competent teaching of maths in IME. Teachers need to be numerate as well as literate, they report, and which the research attests, and to have opportunities to receive on-going CPD in mathematical language skills and communication. Further, there is strong research evidence to show that fostering positive mathematical dispositions are vital to supporting mathematical understanding, and can have a significant impact on children's motivation to learn maths. Creative approaches to teaching maths, such as role play, story-telling, speculation, and outdoor learning, are essential⁵⁴.

However, as the teachers reported in this research, there are few CPD opportunities in numeracy in Irish, and most are in English. Even if such courses were available, finding substitute teachers with the requisite language skills is difficult as there is a shortage of such teachers

Researchers such as Ní Ríordáin and O' Donoghue⁵⁵ have reported that cognisance of the importance of linguistic numeracy in teacher education programmes is important, and that features of the language (syntax, concepts, number relation) may facilitate the teaching of maths in accordance with the idea of Irish-as-resource could be very helpful in this respect. Regarding Irish-as-resource⁵⁶, these researchers suggest, rather than Irish-as-deficit, Irish-as-resource may be critical to ongoing improvements in mathematical teaching, an approach that CCEA may find useful to explore further. This means using the language as a

⁵² Mestere, 1988; Secada, 1991; Bialystock, 2001; Ní Ríordáin and O' Donoghue, 2009; Lauchlan, Parisi and Fadda, 2013; Hartanto, Yang and Yang, 2017; Purpura, Schmitt and Ganley, 2017.

⁵³ Mestere, 1988; Secada, 1991; Bialystock, 2001; Ní Ríordáin and O' Donoghue, 2009; Lauchlan, Parisi and Fadda, 2013; Hartanto, Yang and Yang, 2017; Purpura, Schmitt and Ganley, 2017.

⁵⁴ Setati, M. (2005) Teaching Mathematics in a Primary Multilingual Classroom, *Journal for Research in Maths Education*, 36/5, pp.447-446.

⁵⁵ Ní Ríordáin and O' Donoghue, 2009.

⁵⁶ Ní Ríordáin and O' Donoghue, 2009; Planas and Civil 2013.

communicative resource to encourage discussion, analysis, and problem-solving activities using predominantly Irish or English if resorting to the L1 will enable quicker processing or access to the conceptual equivalent.

While some participant teachers expressed some concern about the best time to introduce English in IME settings, recognising the importance of code-switching, whereby children spontaneously combine their languages in the learning of maths, can also be helpful in motivating pupils to acquire mathematical language and understanding⁵⁷.

Key recommendations:

- Explore how specific features of Irish can be used to teach maths; and
- Explore how maths is taught in undergraduate BEd and PGCE teaching programmes;
- Encourage approaches that foster positive mathematical dispositions in teachers;
- Develop Irish language courses for teachers which explore Irish-as-resource and which enable the development of mathematical talk;
- Identify and engage with external organisations with specific expertise in mathematical teaching, specifically in Irish.

5.2 Support for numeracy and literacy

Pre-school years is important to the development of children's literacy and numeracy, and it is well known that early academic skills are precursors for later academic success and school readiness⁵⁸. There is also research evidence which shows an association between early maths success and literacy: children who demonstrate difficulty in one area are likely to have difficulties in the other because certain aspects of literacy are foundational to the development of maths as is evidenced in problem-solving maths⁵⁹. The findings from this research support these claims. Participant teachers expressed concern that children who struggle with literacy also struggle with mathematical concepts and understanding written problems. Importantly, as a number of teachers have reported here, children who have difficulties with numeracy need to have additional help on a par with the kind of help that is available to children who have difficulties with literacy. Research has demonstrated that high literacy levels and fluency in one-language clearly benefit literacy and fluency in the other.

⁵⁷ See, for example, Planas, 2014.

⁵⁸ Purpura, D.J., Schmitt, S.A., and Ganley, C.M. (2017) Foundations of mathematics and literacy: the role of executive functioning components. *Journal of Experimental Child psychology*, 153, pp.15-34.

⁵⁹ See, for example, Bialystock, 2000.

Curricula tend to recommend specific instructional activities for each aspect of mathematics and literacy such as counting and phonological awareness. CCEA may wish to consider how courses which combine maths and literacy may help.

There was strong agreement amongst the participant teachers that parents who are not speakers of Irish, or who have limited Irish language skills, need to be supported to help their children with homework. If this kind of support is not available, then schools need to ensure that children are adequately supported in their language and mathematical learning in school. One teacher explained how she used the mobile phone to record new words, phrases, and counting so that parents could learn these alongside their children.

Teachers are keen to discourage the idea that it is acceptable to be innumerate or poor at maths. Numeracy, as the research has strongly evidenced⁶⁰, is as important as literacy, and numeracy cannot be divorced from language.

Key recommendations:

- Develop maths resources for pupils which combine numeracy and literacy, rather than teach them as separate components;
- Use technology creatively to communicate in Irish with parents, for example, through the use of specifically designed Apps - WhatsApp, Webchat, and so on.

5.3 Resources

The teachers in this study report that there are very few resources that are available in, particularly Ulster Irish, to teach maths. The widely used Collins text has been translated from English and is not strictly suitable for the Northern Ireland curriculum. Teachers, therefore, spend a lot of time having to adapt and create resources. There are excellent English language online resources⁶¹ which the majority of teachers are willing to use, provided that they can be adapted for the Irish-medium classroom, but few suitable online resources in Irish. What is there is basic and not suitable for teaching problem-solving maths which requires high levels of language input and literacy. Good online resources would help pupils develop as

⁶⁰ See various research cited in the Literature Review. This is a claim that researchers in this field repeatedly make and corroborate.

⁶¹ See, for example, <https://www.weareteachers.com/best-math-websites/> and <http://www.mathisfun.org/great-math-websites-for-teachers>

autonomous and reflective learners, especially in cases where teachers are less confident about their own numeracy skills and how to teach these in Irish.

Teachers regularly use online resources and electronic devices and would welcome creative, interactive, and visual online resources in Irish that can be used in nursery and from P1-P7. They are also very keen to pilot resources that CCEA develop for this purpose. Games that reinforce learning, extend skills, pose questions, include experimentation, have several levels of difficulty, and which present mathematical dilemmas and use, above all, the Irish language are all desired by teachers. As we have argued here, and based on research on numeracy and literacy, the effective teaching of maths cannot be divorced from developing high levels of proficiency in at least one of the languages. Children need the ability to read and comprehend a problem, and to be familiar with technical language. They also need syntactic proficiency and comprehension of math symbols and how they are used in combination with numbers⁶². Good online and interactive sources may help develop these highly desirable skills.

Notwithstanding the differences in Irish dialects, teachers would welcome opportunities for knowledge exchange to share resources across Northern Ireland and the Gaeltacht, removing the need to replicate resources, while offering opportunities to share and generate ideas for maths pedagogy.

Key recommendations:

- Develop and pilot dynamic and interactive online resources in Irish for children in nursery and P1-P7;
- Develop or seek out computer games and visual learning which include, for example, non-routine problems, identifying patterns, intriguing puzzles and which build number sense to increase motivation and engagement, and enhance literacy skills in nursery and P1-P7;
- Develop Apps which teachers, pupils and parents can use in nursery and P1-P7;
- Create opportunities for knowledge exchange among teachers in IME in Northern Ireland and the Republic of Ireland, such as a Teachers' IME Network.

⁶² See, for example, Mestre, 1988.

5.4 Limitations of the research

This is a small-scale study which includes the perceptions, experiences and suggestions of 11 teachers in six schools, four of which are located in a small but growing sector in Northern Ireland, where professionals tend to be known to each other. As we have reported here, while the pool of mathematics teachers in the primary sector is small, the views presented in this report cannot not be generalised to the Irish-medium profession.

In addition, we did not observe how the participants taught maths; we relied on the accounts given by experienced teachers in interviews on quite specific questions. Despite these limitations, the participant teachers' views provide valuable insights into the challenges of teaching KS1/2 maths in Irish, the advantages of teaching maths in the target language, and the kinds of resources they would like to see developed to enhance the teaching of maths. Many of their perceptions and experiences accord with what research in general has already established.

Were CCEA to consider further research on the teaching of maths in IME, the authority could consider increasing the sample size and including observations of classroom practices. Further research might also explore how Irish is used to teach maths in undergraduate teaching programmes.

6. Conclusion

The key findings of this research are that:

- Language proficiency is integral to the teaching and learning of maths;
- Creative, dynamic, and interactive resources in Irish are urgently desired by teachers;
- Opportunities for continuing professional development in maths pedagogy would be welcomed by the teachers in this study.

Learning to do maths is closely connected to acquiring fluency in the language of mathematics. This fluency includes, words, phrases, symbols and abbreviations, along with ways of thinking, speaking and writing that are specific to maths. As has been demonstrated here and in the research, learning to communicate mathematically is key to learning maths, and to learning maths in Irish. Although Irish is not the first language of many pupils who attend IME schools, or their parents, this lack need not impede either their progress in Irish language acquisition, or in maths, provided that teachers communicate mathematically and regard Irish as a resource, and support pupils' progress in these areas. With the teaching of any subject, how the subject is taught is critical. Creativity, imagination, and a positive disposition to teach the subject are critical. Maths can be taught merely as a set of procedures or be taught in ways that encourage pupils to articulate, share, discuss, argue, tell stories, reflect on and refine their understanding of mathematical puzzles and dilemmas. Good mathematical communication requires both approaches (and others besides such as a positive context for learning, for example), and it requires good linguistic competency on the part of the teacher.

The devolved governments and assemblies of Scotland and Wales, and the government of the Republic of Ireland and the United Kingdom, have accorded Gaelic, Welsh, Gaelige and Cornish equal legal status to English, not only out of respect for linguistic and cultural diversity, and to preserve richness of expression, but also to ensure the right to be educated in those languages.

Language is not just oral, written, and symbolic speech that entails cognitive and linguistic processes, and language acquisition; language is also fundamentally relational and socio-cultural: it is localised, social, and meaning-making – and produces identities: Irish speakers, bi-lingual learners, members of the Gaeltacht, or preservers of language and culture in contexts in which English has become the predominant language and threatens the existence of minority languages in the United Kingdom. Language is, in addition, the means by which we struggle for meaning, truth and power, how we assert ourselves, and construct and define others. The availability and quality of resources, whether a national language framework

exists, and the legal and political status of the language, convey how valued a language is to those who aspire to learn to communicate in that language. Language is, therefore, a political and ideological tool: which languages are valued, and which are less valued or discouraged, reveal the social and political standing of language speaking groups.

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7. Appendices

Appendix 1: Information and consent letter



School of Social Sciences, Education and Social Work (SSESW)
Queen's University
69-71 University Street
Belfast
BT7 1HL
[DATE]

Dear [Teacher]

We have been commissioned by CCEA to conduct research on literacy in Mathematics teaching in KS2 in IME. There is some concern that pupils in IME do less well in their numeracy tests than do pupils in English language settings. There may be a number of reasons for this such as, for example: lack of Irish language resources; the absence of an Irish language framework; or differences in how mathematical terms are used in the Irish language.

Why you have been asked to participate

As you are a teacher of maths in an IME setting, we would like to visit your school and interview you about the teaching of KS2 maths. Questions will include: the challenges of teaching KS2 maths; language difficulties and barriers; resources available or required; training and CPD, and so on. We are open to your views on the way forward for the teaching KS2 maths in IME.

What you will be asked to do

Six primary schools have agreed to take part in the research: four in Northern Ireland and two in the Republic of Ireland. The interviews will take place at a time and in a venue that is most convenient to you. The interviews will take about an hour, and will be audio-recorded and transcribed for accuracy. If you wish, you can receive a copy of the transcription. The interviews will be conducted by members of the research team who are: Dr Alison MacKenzie, Prof. Allen Thurston (details below), Dr Nina O'Neill (research fellow) and Joanne O'Keeffe (research assistant).

Outcome of the research

The outcome of the research will be a report on the findings and recommendations for future developments of KS2 maths in IME. The report will be translated into Irish and submitted to CCEA.

Voluntary participation

Your participation is entirely voluntary. You may withdraw at any time from the process without penalty or explanation up until the findings are written up, which we anticipate will be in June.

If you would like to take part in the research please read and sign the consent form at the end of this information letter.

Anonymity and data protection

The ethics committee of the SSESU, Queen's University, has granted ethical approval for this study. The participating schools and teachers will be acknowledged in the report. Direct quotes from participants, however, will be anonymised, unless you expressly want to be named. Data from the audio recordings will be transcribed after each interview and the digital recording destroyed. Transcripts will be stored on password protected and encrypted computers. Hard copies of the consent forms will be stored in a locked cabinet in a locked office at Queen's University. Data will be destroyed five years post study completion.

If you have any questions please contact:

Dr Alison MacKenzie (PI)

A.Mackenzie@qub.ac.uk

028 9097 5903

Professor Allen Thurston (co-researcher)

A.Thurston@qub.ac.uk

Appendix 2: Interview Schedule

Challenges to teaching maths in IME – linguistic (language threshold), familial and resources

- What do you find challenging about teaching maths in Irish?
- Do we need an Irish Language Framework (NI)

Teaching and learning resources

- What resources do you use to teach maths
- What online resources do you currently use to support any aspects of teaching the curriculum?
- What are the top five things you would like from an online resource for mathematics?
- How should content be compiled? Teacher input? Manual?
- Would you be interested in piloting an online resource?

Future developments to address linguistic thresholds, maths literacy, consistency in the use of agreed terminology

- Training and CPD
- Should there be further Irish language immersion/intense immersion pilots?
- What kind of CPD do maths teachers need in IME?